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ABSTRACT

In recent years, a number of claims have appeared in the popular media and press suggesting that television viewing has potentially detrimental effects on human brain development or activity. An extensive review of the published scientific literature finds that virtually no credible experimental evidence appears to exist in the current literature which specifically relates to the effects of television viewing on human brain development. A review of the scientific literature based upon the measurement of small electrical signals from the surface of the scalp as an indicator of cortical brain activity during television viewing revealed two major experimental findings. First, brain wave patterns occurring during TV viewing are quite similar to those that occur during other waking-state activities, suggesting that television viewing should not be characterized as producing a passive or inattentive activity in the brain. Second, television viewing does not appear to be primarily a "right brain" activity. Rather, both cortical hemispheres are involved in the information processing associated with the complex sensory and perceptual experiences that accompany television viewing. New research opportunities for investigating the relationships between television viewing and brain activity should emerge from advances in technology. However, television remains deeply embedded in a complex array of social and cultural factors and is subject to a broad spectrum of individual differences in information-processing capacity, perception, and cognition. (Author/HTH)

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TELEVISION AND THE BRAIN: A REVIEW *

by

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SUMMARY

In recent years, a number of claims have appeared in the popular media and press suggesting that television viewing has potentially detrimental effects on human brain development and/or brain activity. An extensive review of the published, scientific literature provides no evidence to substantiate such beliefs. Virtually no credible experimental evidence appears to exist in the current literature that specifically relates to the effects of television viewing on human brain development. Furthermore, none of the extensive neuroscientific research on brain development of nonhuman species are directly applicable to understanding the potential correlates of television viewing in children.

A review of the scientific literature based upon the measurement of small electrical signals from the surface of the scalp as an indicator of cortical brain activity (the electroencephalogram, EEG) during television viewing revealed two major experimental findings. First of all, brain-wave patterns occurring during TV viewing are quite similar to those that occur during other waking-state activities. Thus, TV-viewing should not be characterized as producing a passive or inattentive activity in

the brain. Secondly, TV viewing does not appear to be primarily a "right brain" activity. Rather, both cortical hemispheres are involved in the information processing that is associated with the complex sensory and perceptual experiences that accompany television viewing.

New research opportunities for investigating the relationships between TV viewing and brain activity should emerge from recent advances in EEG recording technologies as well as the application of 3-dimensional brain-imaging techniques such as Magnetic Source Imaging (MSI), Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI). MRI, in particular, is proving to be a powerful new approach in studies of functional brain organization during a variety of specific tasks and experiences. However, television remains a technology that is deeply embedded in a complex array of social and cultural factors and is subject to a broad spectrum of individual differences in information-processing capacity, perception and cognition. Any serious attempts to understand the potential effects of television viewing on the human brain will require the use of the most advanced experimental and statistical techniques available to modern science.

TELEVISION AND THE BRAIN: A REVIEW

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Introduction

Increasing interest in the potential effects of television viewing on the brain and brain activity, particularly in children, has led to publication of a wide variety of articles and books. Many of these publications present conclusions based upon little more than anecdotal report, speculation, and casual inference. In general, the media, the public, as well as professional educators seem inclined to accept, uncritically, many or all of the following assertions:

- Television viewing is essentially a passive behavior and has adverse effects on children's classroom behavior including increased passivity, shortened attention spans, lack of "stick-to-it-iveness" and reduced creativity (Swerdlow, 1981).

- The rapid pace of some children's television programs contributes to increased frantic behavior and inattentiveness in children (Winn, 1985).

- Television viewing reduces eye movements in young children which leads to retarded reading development (Edgar Gording cited by Moody, 1980; see also Burns and Anderson, 1991)

- Television viewing may result in cortical brain damage, especially in children (Emery & Emery, 1974).

- Television viewing may induce epilepsy (Moody, 1980)

- Television viewing may have hypnotic and possibly addictive effects and change the frequency of electrical impulses in the brain which blocks active mental processing. Extensive television viewing deprives the left hemisphere of developmental time and space thereby disrupting the functions of language and reading. We are rearing a generation of "different brains" and "endangered minds" (Healy, 1990).

Despite the widespread presence of television in our daily lives, relatively little scientific or experimental research has been devoted to the effects of television and video images on the brain either in children or adults. The present review was undertaken to determine whether any major, scientifically based evidence exists that would support the increasingly widespread view that television viewing is detrimental to brain development and/or brain activity. An extensive search of the published, scientific literature was carried out using the "Silver Platter PsychLit" database. Inclusive dates were 1/74 - 9/92 for journal articles and 1/87 - 9/92 for books and book chapters. In executing the literature search, the key words "television", "TV", "media" and "video," were paired with each of the following items:

neural, neurological, neurology, neuropsychology
brain (activity, wave, development, lateralization)
EEG, electroencephalography
cortex
PET, positron emission tomography
CAT scan
lateralization

In addition, over a dozen, recent book chapters and review articles were included in this literature survey:

Anderson & Collins, 1988
Anderson & Burns, 1991
Anderson & Field, 1991
Burns & Anderson, 1991
Chugani, 1992
Chugani, Phelps & Mazziotta, 1987
Greenough, Black & Wallace, 1987; 1992
Greenough & Black, 1992
Greenough & Alcantara (in press)
Reeves, Thorson & Schleuder, 1986
Segalowitz & Hiscock, 1992
Segalowitz and Berge (in press)

Is Brain Development Affected by Television Viewing?

At present, no critically evaluated experimental research has been published that directly address the effects of television viewing on human brain development.[1] An extensive and rapidly expanding research literature continues to provide new insights into the anatomical and functional aspects of brain development in both animals and humans. In particular, this research has shown that so-called "sensitive" or "critical periods" occur early in brain development when the presence or absence of specific environmental factors, sensory and/or behavioral experiences can have profound effects upon the structure of the developing nervous system (see Greenough et al. 1987, 1992; Greenough and Black, 1992 for recent reviews). However, none of this research can be extrapolated directly to an understanding of the potential effects of television viewing on brain development in children.

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1. The standards that are generally applied to the demonstration of scientific evidence require that objective, factual information be obtained by the use of some form of the scientific method. A scientific inquiry involves identifying a problem and designing an experiment in the form of an empirical, testable question or hypothesis. The results and conclusions of the research are communicated through professional journals which publish research findings only after they have been subjected to the peer-review process which involves evaluation by two or more anonymous, qualified reviewers. Scientific reports are generally presented in a specific format that describes the following: (a) the purpose of the study and hypotheses to be tested, (b) the methods and procedures as followed by the experimenter, (c) the results obtained by those methods, and (d) a discussion of the significance and interpretation of those results in relation to previous research and the hypotheses that were tested.

Television is a source of constantly changing, multisensory and multidimensional stimulation that is embedded in a complex cultural, social, and cognitive environment for which there are no known correlates in nonhuman species. Thus, attempts to generalize from research on the developmental effects of experimental sensory and environmental manipulations in nonhuman animals to predict the potential effects of television viewing on the developing human brain are not scientifically credible and should be viewed with great skepticism. Furthermore, differences in brain-growth rates and maturational factors in humans are critical factors (or variables) that contribute to the individual differences that exist in human behavioral and cognitive development. No two individuals respond identically to a complex environmental experience or stimulus. Neither brain development, behavioral development, nor cognitive development are linear over time. Therefore, any attempts to arrive at generalizations based upon correlations between behavior, brain development and specific environmental factors become even more complicated and problematic (see also, Segalowitz and Hiscock, 1992).

At present, no scientifically based evidence exists that indicates television viewing has any demonstrable positive or negative effects on brain organization, including its anatomical and physiological development. Furthermore, a wide range of complex factors which include cultural, socioeconomic, familial, genetic and maturational variables would have to be carefully controlled in any major experimental investigation of the relationships between

television viewing and neurobehavioral development.

Brain Activity and Television Viewing

The brain is composed of billions of neurons which produce electrochemical changes that can be recorded with highly sensitive instruments designed to measure small amounts of electrical activity. In the early 1930's, Hans Berger developed a simple technique for recording "brain waves" of electrical activity from the surface of the scalp. This electroencephalogram, or EEG, has been widely used to measure changes in electrical activity of large areas of the brain, such as the cortex which covers the surface of the brain. The EEG has provided an extremely valuable tool for investigating many aspects of brain function including the daily sleep-waking cycle, mental and cognitive processes associated with sensory stimulation and attention. Medically, the EEG is used for diagnosing the presence of brain damage and brain disorders such as epilepsy. The EEG and specific evoked or event-related potentials (ERPs) also have been used to demonstrate correlations between ongoing brain activity and television viewing in adults, particularly in the field of advertising research.

The EEG provides a continuous record of electrical activity originating predominantly from nerve cells in the cortex of the brain and is recorded from electrodes placed directly on the scalp (see Figure 1a). The electrical frequency composition and size or amplitude of the EEG can change with regard to internal and external variables, brain region and right vs. left hemispheres of the cortex. The EEG may change within a particular recording

session, and the patterns of electrical activity seen in the EEG may vary considerably from one individual to another due to differences in age, gender, handedness, differences in skull thickness, eye movements and/or muscle movements. Various idiosyncratic variations may also exist in neural processing times (Gasser, et al., 1982; Davidson, 1984; see also, Rothschild et al., 1988).

Several different electrical frequencies or rhythms make up the EEG, two of which can be observed in an awake individual. The alpha rhythm (8-12 cycles/second, amplitude of 25-100 microvolts) indicates a resting, inattentive mental state and appears mainly in the parietal and occipital regions (see Figure 1b). Alpha is suppressed when subjects are instructed to pay attention to a stimulus or when they are engaged in active mental activity. The beta rhythm (13-26 cycles/second) also has been used an index of arousal, attention and cognitive activity and predominates in the central and frontal cortical areas.

In many earlier studies, EEG signals were passed though a series of electronic filters that selected the specific band-width of electrical frequencies to be analyzed. More recently, a mathematical procedure called a Fourier transform is often used to convert activity within a specific frequency range to a power measure which represents the amount of electrical energy produced per unit of time. The ratio of EEG power recorded simultaneously in right and left cortical hemispheres has been used to detect

response asymmetries that may occur in relation to the nature of the task being performed by an individual.

A second type of electric brain response, the evoked-response or event-related potential (ERP), represents a specific change in brain electrical response to the presentation of a particular stimulus. The ERP consists of a series of positive and negative changes from baseline activity, with a response time lasting up to 500 milliseconds (1/2 second) after the stimulus ends. ERPs have been used extensively to investigate the neurophysiological correlates of selective attention in humans (see Woods, 1990 for review). Many such studies use computer-averaged data from individual subjects to reduce the influence of random electrical changes or "noise".

Is Television Viewing a Passive Brain Activity?

One of the most frequently repeated claims about the effects of television is that the viewer is passive and becomes mesmerized by the experience. The first study purporting to demonstrate this effect recorded the EEG only from single subject who browsed through a magazine immediately prior to viewing 3 television commercials (Krugman, 1971). Krugman claimed that the subject's EEG response to print was different from the EEG response to television. The EEG to print was described as "active," composed primarily of fast brain waves (presumably beta waves), while the response to television was comprised primarily of slow brain waves (presumably alpha waves). Krugman interpreted these results as consistent with his earlier suggestion that television is primarily

a medium of low involvement compared with print (Krugman, 1965).

The Krugman study is seriously flawed in several respects, however: (1) only a single subject was used for a relatively short test period (15 minutes); (2) the EEG was recorded only from a single, occipital (back of the head) location where alpha activity is generally greatest (Rothschild, et al., 1986); (3) eye movements will reduce alpha; and (4) no quantitative analysis of the data was undertaken. Despite the widespread attention that this study has received, the generalizabilty of its findings have been seriously questioned by other investigators. For example, Rothschild and co-workers point out that both the most beta (fast-wave activity) as well as the least amount of beta-wave activity was elicited during the television-viewing condition. Furthermore, with repetition of the commercials, beta-wave activity diminished. The variable of stimulus repetition is a critical one and may induce the well-known phenomenon of habituation: the reduction in the magnitude of a response to a repeated stimulus event. In general, it appears that little or no effort has been made in the majority of EEG during television-viewing studies to address the issue of which response pattern in a sequence is the most characteristic or representative.

Using a different approach, Shagass and co-workers (1971) studied psychiatric patients in an EEG comparison with normal subjects during television viewing. Three EEG recording sites were used, all from the left hemisphere. No substantial differences in EEG responses were observed between the two groups of subjects; however, most subjects showed a reduction in EEG response amplitude

however, most subjects showed a reduction in EEG response amplitude (characteristic of beta activity) during television viewing compared with the resting, eyes-closed condition. These results suggest that an increase in beta-wave activity and decrease in alpha activity occurred during television viewing. Shagass and co-workers concluded:

> "From the standpoint of EEG changes, the condition of TV viewing may be regarded as one of relatively increased activation..."

In a more detailed study, Appel and co-workers (1979) investigated 6 groups of women who viewed 20 television commercials previously rated as having either high or low viewer involvement. Ratings were based upon prior evaluations obtained from a different group of subjects who also showed different levels of memory recall for those same commercials. Each set of commercials was repeated 3 times in succession. Major findings of this study included lower alpha-wave activity for the television commercials than for a blank television screen. No significant left vs. right hemisphere differences in alpha-wave activity were found, and high-recall commercials were associated with lower levels of alpha-wave activity. Although high-recall commercials produced more brain activity than low-recall commercials, none of the EEG differences among the commercial sets were statistically significant. As the recall-evaluation data and the EEG data came from different subject populations, there was no way to compare EEG differences across individuals due to the content of commercials, message appeal or familiarity effects.

In a closely related study, Weinstein and co-workers (1980) reported lower levels of alpha-wave activity for television commercials than for a blank TV screen and more beta-wave activity for magazine advertising than for television commercials. In this study, highly recalled magazine ads were correlated with greater beta-wave activity. However, only a single EEG recording location was used - the midparietal region (middle of the head) - which generally shows strong alpha-wave activity (Martin, 1991). Thirty women were investigated, but only 18 were selected for inclusion in the final data analysis. These individuals appeared to be selected as those most responsive to differences in the two advertising conditions presented. Thus, the results appear to be biased towards an exaggeration of any differences that may have occurred between the print vs. television viewing conditions.

In a somewhat more elaborate study, Walker (1980) compared EEG activity using 2 occipital (back of the head) recording sites during television viewing vs. reading using 18 male and female undergraduate students. The television program was recorded from a daytime talk show, while the reading task was an essay concerning the biological framework of language. Four other conditions also were investigated: resting with eye closed; eyes open looking at a blank television screen; imagining sitting quietly on a beach; and counting backwards. Some significant EEG differences were observed between tasks, with more beta-wave activity occurring during television viewing than during the eyes closed condition or during the counting-backwards task. Also, more beta-wave activity

occurred during reading than for any other condition, except television viewing. With regard to alpha, significantly more alpha-wave activity occurred during the eyes-closed condition than in any other condition, and more alpha-wave activity occurred during the eyes-open/blank screen condition than during television viewing. Overall, both the highest levels of beta-wave activity and the lowest levels of alpha-wave activity were associated with two conditions: reading and television viewing.

In an innovative and well-executed study using event-related potentials (ERP), Schafer (1978) modified the original methods for studying the evoked-potential correlates of attention developed by Donchin and Cohen (1967). Schafer used a transient, brief flicker of the television screen (a 33-millisecond duration, faint increase in brightness of the picture) as a probe stimulus while recording cortical evoked potentials from subjects viewing various programs. Schafer termed these responses, "TVEPs" and used them to investigate programs of widely different content (i.e., "Face the Nation" vs. erotic movies). Significantly smaller ERP response amplitudes were observed in the late response components of the ERP when viewers judged the television programs as interesting. These results suggest that as attention to program content increased, a smaller EEG response occurred in the presence of the irrelevant probe stimulus - flicker of the television screen. The TVEP can be used to study attentional and cognitive aspects of TV viewing in "real-life" conditions, but this technique has not been adopted by other investigators.

With regard to the possiblity of training visual attention, using alpha-wave feedback, children were used as subjects in preliminary studies reported by Mulholland (1974). This approach was based upon the earlier demonstrations that individuals receiving biofeedback could learn to control the occurrence of alpha and other brain rhythms. Mulholland demonstrated that the alpha-biofeedback technique could be used on children as young as 5-years of age and with children having special attention problems. In one task which he described as a "pilot study," the television set remained on as long as the child showed no alpha-wave EEG activity. The child was to "try to keep the TV set on." Therefore, cortical activation was increased by the child producing increased attention to the TV.

Based upon these preliminary results, Mulholland states that the high level of alpha observed with the programs used "...led me to speculate that children may be spending a huge amount of time learning how to be inattentive or how to operate at a low level of attention while watching TV before they get to school." He further recommends that "...more research is surely indicated here, since children spend a huge amount of time watching TV before they start school." However, Mulholland appears not to have followed his own advice to go beyond this preliminary work to conduct more extensive investigations involving larger numbers of subjects.

In contrast, a series of 6 studies was conducted by Miller (1985) over a 2-year period using 56 volunteer college students as subjects. Miller used three EEG recording sites: temporal, parietal

and occipital regions of the scalp. These subjects viewed several situation comedies, several drama series programs, and a film-criticism program. EEG data were averaged in 5-minute time segments and were analyzed by two, independent evaluators who were not aware of the nature of the experiments. The results indicated that forty-nine of the subjects produced dominant beta-wave activity, while only 6 subjects produced dominant alpha-wave activity. Miller concluded that television viewing is neither predominantly an alpha-wave activity, nor a right-hemisphere activity. Neither cortical hemisphere tended to dominate during television viewing. Furthermore, beta-wave activity tended to increase over a half-hour viewing period, while alpha-wave activity decreased. Miller concluded that:

> "...television viewing produces brainwave patterns that are much like those of other waking state activities:
>
> "..television viewing is predominantly a beta brainwave pattern reflecting a more active than inactive viewer..."
>
> "...with respect to our brainwave patterns, television viewing appears to be nothing special."

In summary, the available evidence from all of these studies fails to support the notion that television viewing is a passive or inattentive activity. Also, Burns and Anderson (1991) have concluded that the weight of evidence from experimental psychology studies strongly support the conclusion that television viewing is an active, cognitive process:

> "...television may draw on an attentional system that is no less voluntary or active than the attentional system invoked when reading."

Is Television Viewing a "Right Brain" Activity?

A second popular claim asserts that television viewing is primarily a "right brain" (more accurately, a right cortical hemisphere) activity. However, the experimental, published literature using EEG measures in well-designed experiments does not support such a conclusion. For example, Weinstein and co-workers (1980) found no evidence to support the belief that television advertising produces greater right hemisphere activity; nor did Alwitt (1985) or Hansen (1981) in their extensive reviews of the published literature.

Appel and co-workers (1979, described earlier) hypothesized that television commercials would generate more right-hemisphere EEG activity than left-hemisphere activity, and that commercials producing higher memory recall scores would generate higher levels of activity in the left hemisphere. Large individual differences were found in the amount of alpha activity generated, but this study failed to provide evidence to support either hypothesis. The authors concluded that television commercials that produced the greater amount of brain activity, regardless of hemisphere, were recalled with greatest accuracy. These results are consistent with the well-established, inverse relationship between alpha-wave activity and attention. As mentioned earlier, a major problem with this study is that the recall data and the EEG data were obtained on different groups of subjects, with no consideration of possible individual differences in message appeal or content.

Rothschild and co-workers (1988) recorded from an occipital

(back of the head) location in 21 women who viewed a 27.5 minute videotape composed of 4.5-minutes of 9 commercials, followed by 2 minutes of a dark screen, followed by 21 minutes of television programming. After the television viewing session, subjects were given a distractor in the form of a questionnaire, followed 30 minutes later by a recall and recognition test relating to the 9 commercials. Hypotheses tested in this study concerned hemispheric differences and the reliability, replicability, and consistency of the EEG data obtained. Data analyses were based upon EEG data in the alpha frequency range for left and right hemispheres, separately. Not surprisingly, the results indicated that each commercial influenced the EEG in a unique manner, with verbal components of a commercial being more likely to be processed in the left hemisphere, while nonverbal components showed greater right hemispheric effects. These effects were characterized as "quite subtle", leading the authors to conclude that television commercials are processed bilaterally in the cortex, rather than unilaterally.

In a more extensive and statistically detailed study using the same experimental procedures and analyzing both EEG power and hemispheric dominance, Rothschild and Hyun (1990) found that memory for components of television commercials was significantly correlated with changes in EEG patterns during viewing of commercials. A total of 9 different stimulus variables were identified within the commercials, including 3 verbal and 6 nonverbal variables. A time series was created for each commercial

based on the half-second in which each new stimulus appeared. Well-remembered commercial components were associated with a longer period of alpha-wave blocking (a sign of attentiveness), and a delayed period of left-hemisphere dominance. The reverse was true for those commercial components that were poorly remembered (i.e., a higher resting level of brain activity and a delayed period of right hemisphere dominance.)

Based on this study, Rothschild and Hyun suggest that a great deal of information processing occurs in the brain during a 30-second commercial that cannot be easily assessed by retrospective and introspective evaluations. They concluded that their results support a bilateral model of hemispheric activation in which the cerebral hemispheres work together in processing complex stimuli, but with some specialization. Verbal components are more likely to be processed in the left hemisphere and nonverbal components in the right hemisphere. The authors further concluded that:

> "The pop psychology view of unilateral processes has not been supported by the work presented in this article."

Other evidence from studies of hemispheric asymmetry indicate that the right cortical hemisphere, particularly the frontal lobe, shows greater activation during negative emotions, while the left is more active during positive emotions (see Springer and Deutsch, 1989, for review). This asymmetry exists in infants as well (Davidson & Fox, 1988; 1989; Fox, Bell & Jones, 1992; see also Segalowitz and Berge, in press). Several recent articles have reported hemispheric differences in cortical arousal in relation to positive vs. negative television scenes (Reeves, et al., 1987;

Schellberg, et al., 1990), with greater cortical arousal occurring to negative than to positive scenes. Greater occipital than frontal-lobe arousal also was observed by Reeves and co-workers (1989) who further suggested that the conscious interpretation of television messages may be influenced by differences in hemispheric specialization. However, they emphasize that:

> "...a television scene will never be an example of a single message element and nothing else, even if one part of the message is featured."
>
> " The problems with stimulus complexity are a price for dealing with television. It would be impossible to find or create television messages that varied on a global attribute like emotional tone but did not differ on other criteria."

Thus far, only one experimental study has been published involving children and left vs. right hemispheric differences during television viewing. Yoshida and Kaneko (1989) recorded left-hemisphere EEGs from frontal, central and occipital scalp electrodes in 4 males (6-13 years of age) while the children viewed an animation video. EEGs in 3 frequency bands were recorded, the theta wave (4-8 cycles/second), alpha wave (8-13 cycles/second) and beta wave (15-30 cycles/second). The authors interpreted their results as providing evidence that frontal-lobe activity in the alpha frequency range was more affected by TV viewing than were central or occipital regions. However, a detailed examination of their limited data show only small differences between frontal and occipital recording sites, and these were not statistically evaluated for significance. In addition, the small number of

subjects used and the lack of a rigorous experimental procedure, seriously limit the generality of the results obtained.

Schellberg and co-workers (1990) used video films to test the hypothesis in 10 adult males that EEG response characteristics would be different among films in relation to postviewing, subjective ratings and would do so to a greater extent with regard to EEGs recorded from the right hemisphere than from the left. Topographic EEG activity was recorded for several frequency ranges while the subjects viewed video films selected to induce continuous emotional stimulation. The authors interpreted their results as being consistent with their hypothesis that affective processing occurs in the right hemisphere. A correlation between arousal of the right-anterior and left-posterior cortical regions was also reported. Right-hemisphere response characteristics which measured the degree of synchrony between frontal and temporal areas also seemed to be sensitive to subtle changes in verbal-visual cues. This particular approach to EEG topographic mapping using complex video stimuli and highly quantitative EEG response-analysis techniques appears to provide detailed information about the ways in which different cortical regions process cognitive information during television viewing.

In summary, the weight of published evidence does not support the notion of a predominantly right-hemisphere mode of information-processing during television viewing. Rather, it appears that both cortical hemispheres are involved in the complex visual, auditory

and perceptual experience associated with television viewing, as is true for other cognitive and conscious activities.

Future Research Prospects

The EEG and ERP techniques show substantial promise for what Rothschild, et al. (1990) have termed, "the new field of micro-information processing" with regard to describing the relationships between brain activity and television viewing. Although they have not been applied to research on television viewing, several recent advances in EEG technology offer relatively low-cost, functional brain-imaging capabilities, with sub-second time resolution and remarkably good localization of superficial cortical activity. The recent technical advances (Gevins, et al., 1987; 1992; Gevins, 1990) that enable simultaneous recordings to be made from over 120 scalp electrodes improves the spatial resolution and detail of EEG topographic recordings. Also, new athematical procedures have been developed which correct for distortions as well as analytic methods to measure processes occurring in distributed cortical networks while subjects are performing simple cognitive tasks.

Nevertheless, it should be remembered that the EEG and other electrophysiological measures are only indirect correlates of cognitive activity and mental experience. As such, they are susceptible to sources of error from eye and muscular movements and show considerable variation in regional activity patterns, even within a single individual. As Donchin (1985) has pointed out:

> "The mind, when approached psychophysiologically, is not any more an open book than it is when approached in any other way. It is complex, multilayered and often deceptive."

A variety of new, 3-dimensional, brain-imaging techniques are now in existence that may eventually be used to investigate brain activity during television viewing. These new techniques include:

1. Magnetic Source Imaging (MSI) takes advantage of the magnetic fields that accompany the bioelectrical fields generated by neuronal activity within the brain. These magnetic fields can be measured at the surface of the head (which is transparent to magnetic fields) as a magnetoencephalogram (MEG). Essentially, the MEG is the magnetic counterpart of the EEG. This noninvasive technique provides high-resolution localization of cortical activity that occurs during sensory, motor and cognitive functions such as mental imagery, and working memory (Kaufman, et al., 1990; 1991). EEG recording arrays with 19 and 37 sensors are now commercially available, and wholescalp arrays of 60 and 122 sensors have been developed so that activity over the entire scalp can be monitored simultaneously (Williamson, 1992).

2. Positron Emission Tomography (PET), is an invasive procedure that uses radioactive contrast agents to describe the distribution and absolute rates of local, cerebral glucose utilization (glucose is the metabolic fuel used by all active cells). The PET technique has the major disadvantages of safety concerns, relatively coarse resolution (3.5 x 3.5 x 4 mm) and slow speed of temporal resolution (5 minutes. The PET technique is expensive and interpretation of the results are often problematic (Segalowitz, personal communication). Chugani and co-workers (Chugani and Phelps, 1986; Chugani, et al., 1987) have successfully

used PET techniques to describe the maturational trends in the human brain from birth to adulthood.

3. Magnetic Resonance Imaging (MRI) techniques utilize blood-borne, oxygenated hemoglobin in high magnetic fields to create functional brain maps with high spatial (1 mm x 1 mm) and temporal resolution (milliseconds) that enable the tracking of real-time changes in oxygen exchange associated with blood flow in the brain. MRI is one of the least invasive measurement techniques yet developed and, therefore, it has great potential for experimental studies of functioning brain organization, cognitive activity and task performance in awake, responding individuals (Belliveau, et al., 1991).

At present, no one can accurately predict which of these new methods will prove to be the most useful in clarifying the relationships that exist between the complex stimulus of television and the physiological and cognitive processes that accompany television viewing. However, future prospects for such research are very bright and are well within the experimental capabilities of contemporary neuroscience. Above all, it must be remembered that television is a technology that is deeply embedded within complex cultural and social matrices. Any serious attempts to investigate the potential effects that television viewing might have upon human brain development and/or information-processing capabilities will require the most sophisticated experimental and statistical tools that modern science has at its disposal. Ultimately, only the accumulation of scientifically based information can effectively

dispel much of the mythology and amateur theorizing that presently underlie popular beliefs about the effects of television viewing on the human brain.

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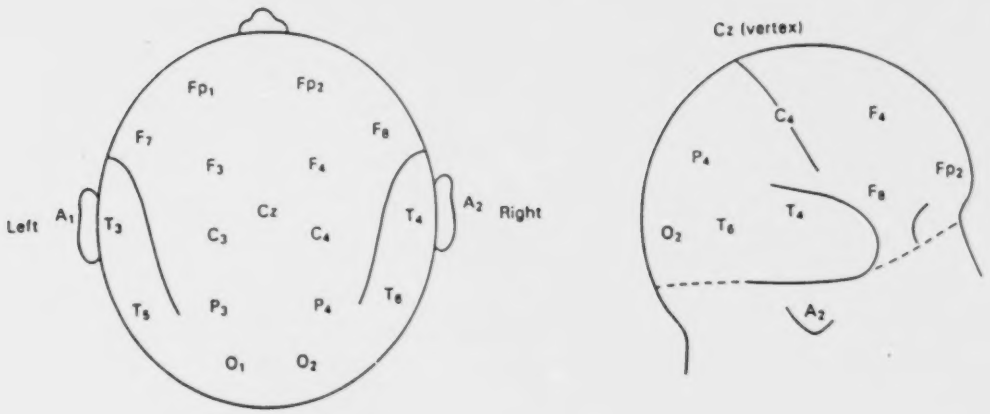

Figure 1a

The standard placement of EEG recording electrodes at the top and side of the head. Abbreviations for multiple electrode placements are: **A**, auricle; **C**, central; **Cz**, vertex **F**, frontal; **FP**, frontal pole; **O**, occipital; **P**, parietal; **T**, temporal. The multiple electrodes placements overlying a given area (eg., temporal) are indicated by numerical subscripts. Placement C_4 overlies the region of the central sulcus.

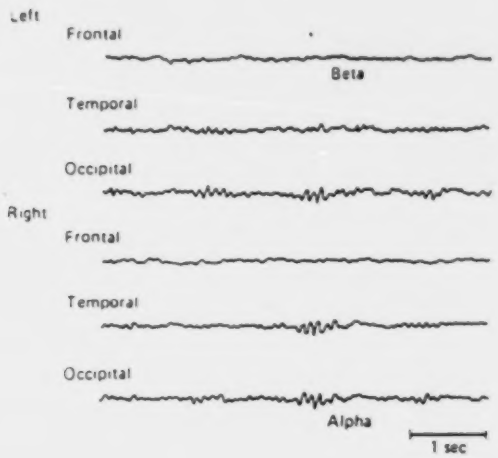

Figure 1b

The EEG recorded in a human subject at rest from the scalp surface at various points over the left and right hemispheres. Three pairs of EEG electrodes are positioned so as to overlie the frontal, temporal, and occipital lobes. (See Figure 1a for the standardized placement of EEG electrodes.) *Beta* activity is recorded over the frontal lobes. This is the EEG activity with the highest frequency and lowest amplitude. *Alpha* activity is recorded in the occipital and temporal lobes. This is a signature of a brain in a relaxed and wakeful state. The presence of alpha activity in the occipital lobe suggests that the subject's eyes were closed.

(Figures modified from Martin, J. H. 1991)